

**THE AEDC AEROSPACE CHAMBER 7V**  
**An Advanced Test Capability for Infrared Surveillance and Seeker Sensors\***

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**ABSTRACT**

An advanced sensor test capability is now operational at the Air Force Arnold Engineering Development Center (AEDC) for calibration and performance characterization of infrared sensors. This facility, known as the 7V, is part of a broad range of test capabilities under development at AEDC to provide complete ground test support to the sensor community for large-aperture surveillance sensors and kinetic kill interceptors. The 7V is a state-of-the-art cryo/vacuum facility providing calibration and mission simulation against space backgrounds. Key features of the facility include high-fidelity scene simulation with precision track accuracy and *in-situ* target monitoring, diffraction limited optical system, NIST traceable broadband and spectral radiometric calibration, outstanding jitter control, environmental systems for 20 K, high-vacuum, low-background simulation, and an advanced data acquisition system.

**INTRODUCTION**

AEDC, located on the Arnold Air Force Base, TN, offers a wide range of advanced aerospace ground test capabilities for the DoD and civilian community. The Space Test Complex, shown in Fig. 1, provides a number of space simulation facilities, including a low-background infrared sensor test capability in the 7V Chamber.

**Developing a Strategy for Ground Testing Infrared Sensors**

To keep up with advances in the design of surveillance sensors and kinetic energy weapon (KEW) interceptors, new test capability must be developed which utilizes the many advantages of ground testing. Some of these advantages include:

- Shortened system development time and lowered risk with flight tests;
- Cheaper development and test costs;
- Simulation of some test conditions on the ground that are impractical or impossible on orbit;
- Easy separation of test parameters which can be varied quickly, reproduced accurately, and repeated as many times as necessary to establish good statistics on test data; and
- Good access to the sensor or test equipment to diagnose problems rapidly and resume testing in a timely and cost-effective manner.

Despite these advantages, ground testing is limited by programmatic constraints and available technology to fully simulate real-world conditions. Limitations include number of objects and complexity of backgrounds, availability of optics to cover large aperture/large field of view sensors, and ability to simulate zero gravity. Compromises must be made and conflicting requirements of the real world with the limitations of the test world must be resolved. The strategy to accomplish this difficult job is defined as test methodology. Its goal is to design the test capability to meet mission needs with innovative test techniques which simulate the real world with high fidelity, but within the constraints of available technology, cost, schedule, and risk.

**Test Capability at AEDC to Support Sensor Development**

Since the late 1960's, 35 IR sensor tests have been conducted in the 7V (ref. 1). However, the increasing complexity in mission needs made it necessary to upgrade this facility and augment it with other test capabilities to support advanced sensor development. Seven years ago AEDC initiated a comprehensive plan (ref. 2) to improve its sensor test capabilities to support development of surveillance and KEW systems. This plan, outlined in Fig. 2, is designed to address test needs during all phases of sensor development. In the initial stages, component testing at the focal plane detector chip or module level is essential to

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\*The research reported herein was performed by the Arnold Engineering Development Center (AEDC), Air Force Materiel Command. Work and analysis for this research were done by personnel of Calspan Corporation/AEDC Division, technical services contractor for the AEDC aerospace flight dynamics facilities. Further reproduction is authorized to satisfy needs of the U. S. Government.

understanding basic detector performance and evaluating producibility issues. This capability is provided in AEDC's Focal Plane Characterization Chamber, which has been involved over the last 5 years in a number of detector development programs. Once the basic module design is proven, the next step in developing a sensor system is integration of the modules into a complete focal plane assembly with data processors and high-level algorithms. Test issues at this step are addressed in the Focal Plane Array Test Chamber, which uses a laser-based scene generation system to "paint" complex scenes directly on the focal plane. The final step in sensor development integrates the focal plane with its complete mission-level processors and algorithms with the sensor telescope, scan gimbals, and other interfacing systems. Two facilities are available at AEDC to meet system-level test needs: the 7V Chamber, operational since February 1994 for basic sensor calibration and characterization; and the 10V Chamber, scheduled for completion in 1996 for advanced mission simulation. This paper describes the 7V Facility which is shown in Fig. 3.

## TEST METHODOLOGY AND REQUIREMENTS

Requirements for the 7V flow out of a test methodology developed at AEDC to meet test demands for advanced sensor systems based on four premises:

- Test facility requirements must be based on a thorough understanding of mission needs, performance issues, threat definition, and sensor operational environments. Simulations must address critical issues which drive sensor designs, stress their performance, and ultimately dictate mission success. Furthermore, the facility must be versatile considering a range of test articles designed for a number of mission objectives.
- To evaluate critical test issues in the most timely and practical manner, it is necessary to test early and often through the sensor development process. Evaluation of specific issues are more cost effective at the component level than at higher system levels. An example might be access to analog signals from a focal plane which might be impossible at the sensor level unless the designer considered system level testability. This approach simplifies requirements for a given facility by limiting its objectives to what is practical and necessary. However, it requires program involvement early in the development process to include testability in the sensor design and ground testing in the overall program schedule.
- The test facility must be designed such that individual simulation systems are modular. This allows test needs to be satisfied in the most timely and economical manner by choosing equipment for given test objectives without major modification to the test configuration.
- At the full sensor system level, it is critical to maintain fidelity of the simulations while recognizing the practical constraints outlined above. This is accomplished in the 7V by breaking the overall mission into testable phases where parameters are separated for the test objective under consideration. The simulations are set up in a piecewise real time for the particular phase under test with sufficient overlap for continuity in reconstructing mission timelines.

The methodology described above defines test needs necessary to evaluate sensor performance against projected mission issues; matches the test facility capability to critical sensor design parameters; and identifies the simulations, phases, and timing necessary for good fidelity to the real world. Functional requirements for the 7V are defined from this methodology in five key capabilities defined in Table 1. The technical capabilities of the 7V Facility which fulfill these high-level functional requirements are outlined in Table 2. As indicated, most of these were verified during the cooldown of the facility in February 1994. The remaining capabilities await delivery of the Complex Target Simulator and the Sensor Positioner in 1995. All of these capabilities will be discussed in the sections following a brief description of the overall facility.

## FACILITY OVERVIEW

The role for 7V is to provide advanced calibration and performance characterization for both surveillance sensors and KEW seekers. Calibration includes not only the traditional role of radiometric calibration, but also goniometric calibration to evaluate accuracy of sensor target tracking and seeker guidance commands. However, the key to evaluation of sensor mission performance is thorough understanding of its operational characteristics. This includes establishing performance envelopes, defining interrelationships of key variables, identifying nonlinear behavior, and measuring timing and sequencing.

The implementation of these test objectives in 7V is illustrated by a functional diagram shown in Fig. 4. All of the simulation equipment is mounted on a rigid optical bench within the vacuum chamber. For low-infrared background, all equipment along with the bench is cryogenically cooled and totally enclosed inside a light-tight cryogenic liner. The scene is projected into the sensor under test by reflective collimation optics to simulate the target range, and a scan mirror to simulate scene movement for scanning sensors. The sensor is mounted in a separate antechamber on a three-axis gimbal support system for alignment. This

allows the sensor to operate in an ambient vacuum environment interfacing to the low-background test volume through a cryogenically cooled labyrinth baffle. The chamber, antechamber, and optical bench provide a rigid monolithic structure to control relative line-of-sight motions between the scene and the sensor. Jitter is controlled by mounting the entire facility on pneumatic vibration isolators to attenuate seismic inputs and equipment vibrations. Other support systems provide environmental conditions, utilities, cleanrooms, and data acquisition, control, and monitoring functions for the chamber and test equipment, and the sensor under test. The remaining sections describe each of these systems.

## **FACILITY SYSTEMS**

Figure 5 gives an overview of the 7V Facility providing photographs of the vacuum chamber, cryo/vacuum systems, and the modernized cleanrooms and control room.

### **Chamber Systems**

The Chamber Systems, extensively modified from the original 7V Facility, include the Vacuum Chamber, Sensor Antechamber, the Vibration Isolation System, the 7 ft in diameter by 23 ft long a with 7-ft-diam by 7-ft-long antechamber on one end. The antechamber has a separate vacuum pumping system and a gate valve to isolate the test article from the main chamber during pumpdown/cooldown to protect it from contamination. The entire chamber shell is supported from building structure on eight pairs of pneumatic vibration isolators to control jitter from ground vibrations. Relative movement between key optical elements such as target sources, mirrors, and the sensor is minimized by stiffness of the vacuum shell structure and the internal helium-cooled optical bench. As shown in Fig. 5, the bench is semi-cylindrical in cross section, about 20 ft long, and weighs 5,000 pounds. It is fabricated from welded aluminum plate and cooled through continuous aluminum extrusions welded to the internal surfaces. To remove weld stresses and stabilize the structure, the entire bench was stress relieved to near annealed conditions prior to final machining. The bench is supported from the vacuum shell by a fixed stainless pedestal in the center. Flexure supports at each end accommodate axial and lateral thermal contraction during cooldown. These supports offer thermal isolation of the cryogenic equipment and provide a rigid structural tie between the technical equipment mounted on the bench and the vacuum shell. For ease of access to the equipment, the bench can be removed quickly from the chamber by lowering it onto rails mounted on the bottom of the shell. The cryogenic, low-background test volume is enclosed by a cold liner which covers the top of the bench and each end. It is constructed from aluminum, cooled with welded extrusions, and coated internally with a flat black, low reflectance paint to absorb stray light. All external surfaces of the bench and liner are wrapped with 30 layers of perforated aluminized Mylar<sup>®</sup> to control radiation heat loads. Total steady-state refrigeration requirement to maintain the entire 6,500 pounds of equipment at 16 K is about 900 watts.

### **Environmental Systems**

The Environmental Systems provide vacuum and cryogenic conditioning, contamination monitoring, and utilities for the facility. The Vacuum System consists of a conventional oil-sealed roughing pump and oil-free high-vacuum pumps. The initial evacuation is accomplished by the 140 CFM roughing pump down to 10 torr. This relatively high vacuum level prevents oil backstreaming from free molecular flow. Other oil contamination safeguards include three separate liquid nitrogen traps and an in-line absorbent filter. At 10 torr, the roughing pump is shut down, and three dry, oil-free molecular drag pumps backed by individual membrane pumps are brought on to evacuate the chamber to 0.1 torr. At this point, two 1,100 l/sec turbomolecular high-vacuum pumps backed by the drag pumps bring the chamber to  $10^{-5}$  torr range. Cryogenic cooling is then started cryopumping the chamber to the low  $10^{-7}$  torr range.

Cooldown of the facility to low background conditions is accomplished by a 3.4-kW closed cycle gaseous helium refrigerator. This system provides low -pressure, cryogenic helium gas at 10 K to four parallel circuits used to cool the optical bench, liner, and the test equipment. Each circuit is independently controlled with supply and return valves and in-line heaters for automated flow and temperature control. The vacuum and cryogenic systems bring the chamber to stable test conditions of 16 K in about three days. This refrigeration system is capable of controlling the chamber at higher temperature levels, if necessary, for higher background sensors. This would save time in getting to test conditions and offer better mission simulation.

Contamination control is critical to protecting the sensor and the test equipment from chemical and particulate contamination. This control is maintained by careful design and selection of materials, the use of cleanrooms, and careful pumpdown/cooldown procedures to cryopump contamination on noncritical surfaces. To ensure a contamination-free environment, the vacuum volume is monitored by several active and passive systems. For *in-situ* monitoring of cryo-condensable contaminants, the

internal cryogenic test volume is equipped with two quartz crystal microbalances for a continuous record of any cryopumped contamination on the optics. These are attached to each main mirror mount tracking the same thermal history. For specie identification, the external vacuum outside the liner and within the antechamber is monitored by two mass spectrometers which continuously sample gases being pumped by both vacuum systems. For identification of non-condensable contaminants, the entire chamber within and without the cryogenic test volume is monitored with witness plates which are measured in a transmission spectrometer after every test.

### **Building Modifications**

The cleanrooms and control room shown in Fig. 5, were modernized and enlarged to support the increased test capability. The cleanrooms provide a controlled temperature and humidity environment for the sensor during installation with excellent protection from particulate contamination down to Federal Standard 209 - Class 100 (air filtration to limit exposure of critical optics and electronics to a maximum of 100 particles/cubic meter of 0.5 microns or less). Controlled access to the test article is also provided with cipher-locked doors for fully classified testing to the Secret level or higher if necessary. The Control Room is TEMPEST shielded for classified operations providing environmental control for all chamber and user data systems.

### **SCENE SIMULATION**

The typical mission scenes for exo-atmospheric surveillance and interceptor sensors are illustrated in Fig. 6 showing threat scenarios overlaid on natural space or earth-limb backgrounds. Since the objective of the 7V chamber is to provide sensor calibration and characterization, simulation requirements are simplified in comparison to the more complex scenes provided in other AEDC facilities. The primary objective of the 7V scene simulation is high fidelity to target radiometrics and precise location of individual targets or high-density target clusters. Background simulation is presently limited to variable intensity uniform space, a possible star pattern or a simple spatial gradient to simulate an earth limb. (The earth limb is not presently available but planned as a future upgrade.) Three target simulations shown in Fig. 6 can be tracked across the sensor's field of view: Closely Spaced Object (CSO) simulation of two or more targets separating into fully resolved targets, a complex cluster of targets expanding from a clump to fully resolved cluster, and a blooming triangular or circular target.

#### **Closely Spaced Object Simulation**

Resolving closely spaced objects into discrete targets is an important task for both surveillance and interceptor sensors. The ability to accomplish this as soon as possible in the mission increases the time available to discriminate decoys and identify targets, establish trajectories and hand over track files to interceptors, centroid targets through penetration aids and establish aim points, and identify hit point for kill assessment. The 7V target system provides CSO simulation using two integrating sphere graybody sources overlaid by a CdTe beam combiner. The beam combiner is cut with a 0.5-deg wedge to reflect ghost images out of the field of view of the collimator. One source moves relative to the other while both are tracked across the field of view of the sensor on a precision X-Y translator. Either source has independent control of temperature and radiometric output. The source intensity can also be dynamically varied to simulate coning targets. For multiple CSO patterns or variable source size, both sources are equipped with output aperture wheels providing up to 30-user selectable patterns. A schematic and photograph of the CSO System is shown in Fig. 7 along with capabilities for this source.

#### **Complex Target Simulation**

Simulation of complex target scenarios is provided an advanced scene generator, called CRISP for Cryo/vacuum Resistor Array Infrared Scene Projector. Honeywell Corporation is developing this capability for AEDC with delivery in 1995. Based on etched silicon micromachining technology, the CRISP generates dynamic patterns of 1 to 400 independent targets using an array of 512 by 512 heated resistor pixels. Each 30- $\mu$ rad point target is generated by a subarray of 6 by 6 pixels. By sequentially heating and cooling adjacent pixels, the target appears to move in 5- $\mu$ rad steps. The microphotograph in Fig. 8 shows several individual 90-micron-square pixels. Each is individually addressable over a temperature range of 20 to 400 K controlled within 1 K with response of 10 Hz over the full range. Because any of the 36 pixels per target will image as a diffraction limited point target, the target intensity can be varied over a dynamic range of 36 at constant temperature. The resistor is supported on top of the addressing and control electronics by a thin silicon bridge which isolates the heat and prevents crosstalk. The two-layered structure also increases the fill factor of each pixel to 90 percent. The combination of an optical reflector under the pixel and titanium nitride black emitter surface increases the emittance to about 70 percent with spectral characteristics of a graybody. Presently the CRISP array chip and control electronics are complete and were successfully tested at 20 K. Funding limitations have stretched completion of the controls and software into FY95, but the technology to produce high-resolution, complex scenes is in hand and offers the 7V a unique test capability unmatched anywhere else.

## Expandable Target System

The third scene scenario shown in Fig. 6 is an expandable target for seeker target centroid testing. As shown in Fig. 9, both circular and triangular targets of various aspect ratios can be simulated by using a dynamic cryogenic iris in conjunction with an aperture wheel. To simulate target intensity increase due to range closing, the source also has a linearly variable circular attenuator to dynamically change source intensity over two orders of magnitude. In conjunction with the Scan Mirror, the expandable target can be swept across the seeker field of view at high speed to simulate the effect of miss distance. This is a valuable feature to test seeker centroiding ability at high closure speeds.

## Background Simulation

Simulation of uniform space backgrounds is accomplished by direct projection of a blackbody radiator into the sensor under test. As shown in Fig. 10, this source is located out of the sensor's field of view next to the primary mirror. It illuminates the entrance aperture of the sensor, overfilling its focal plane with uniform illumination. The source is a conical blackbody fitted with a 16-position aperture wheel to vary background intensity at constant source temperature. It is mounted on a translator stage so it can be parked outside the field of view for background or moved on axis when used by itself for sensor focal plane flood source testing.

A conceptual design and prototype of an earth limb simulator is complete but is not implemented in the 7V. This design utilizes an array of individually heated wires located out of focus to provide an intensity gradient simulating earth limb.

## RADIOMETRIC AND GONIOMETRIC CALIBRATION

Calibration of the 7V simulations is divided into two functions - radiometric calibration traceable to the broadband standards of the National Institute of Standards and Technology (NIST) and goniometric calibration for measurement of target position and track accuracy. As shown in Fig. 3 and schematically in Fig. 11, the Radiometric Calibration System (RCS) consists of the Calibration Source for broadband and spectral input to the sensor under test and the Calibration Monitor for *in-situ* measurement of all the source outputs over broadband and spectral regions. The goniometric function is provided by the Alignment Monitor System (AMS), which incorporates an infrared camera to image the scene projected into the sensor. Both monitors are located in an antechamber just in front of the sensor. Either monitor can be used by deploying a gimbaled flat mirror into the collimated beam to direct radiation into focusing optics which image the scene onto IR detectors.

### Radiometric Calibration

The RCS Calibration Sources provide several operational modes as point or extended sources with either broadband or spectral output. Low-level, broadband output is provided from an integrating sphere illuminated by a blackbody through a 16-position aperture wheel. This technique provides wide dynamic range of 3.5 orders of magnitude at any temperature over an operating range of 150 to 500 K. The unisphere source is supplemented by a bare cavity blackbody with variable output aperture for an additional order of magnitude at the upper end of the dynamic range. Either source can be attenuated by three neutral density filters to lower the dynamic range by an additional one to three orders of magnitude to a minimum intensity of  $10^{-18}$  W/cm<sup>2</sup>. Including temperature variation, the total dynamic range is almost eight orders of magnitude. Spectral output is provided by the cavity blackbody dispersed by a three-segment Circular Variable Filter (CVF). This provides narrowband energy over 2.5 to 14.5 microns with bandwidth varying from 1.0 percent at the lower end to 1.8 percent at the upper end.

The Radiometric Calibration Monitor System samples the output from any source for radiometric intensity and uniformity. To measure radiometric output, the selector mirror reflects part of the collimated radiation into a 10-cm imaging mirror which focuses the source onto a 2-mrad-square Gallium-doped Silicon detector. The detector operating at 16 K responds over a band of 3 to 18 microns. It is calibrated *in-situ* by a secondary standard blackbody, previously calibrated at NIST to 1-percent accuracy. Spectral calibration of any source uses an identical CVF inserted in front of the Si:Ga detector. All of the sources were calibrated by this approach during the February, 1994 test. Results show overall radiometric uncertainty for the system to be less than 5 percent, with repeatability of 2.8 percent for 17 separate measurements made throughout the 12-day test. This performance is outstanding and is believed to be the best radiometric calibration capability available today.

### Goniometric Calibration

Calibration of target position is accomplished by the Alignment Monitor System (ref. 3) shown in Fig. 12. This device, built for AEDC by Mission Research Corporation, is an infrared sensor equipped with a 256 by 256 Indium Antimonide (InSb)

focal plane which covers a 0.75-deg square portion of the Collimator field of view. (The system can be upgraded to 1-deg square field coverage using 512 by 512 focal plane technology when it becomes available.) The imaging optics cover a circular field of view of 1.5 deg with an all-reflective, highly corrected anastigmatic design using nickel-plated aluminum mirrors. The complete system is actively cooled by the 7V gaseous helium system to 20 K, while the focal plane is independently controlled within a range from 30 to 50 K depending on sensitivity needed. The AMS and its image analysis electronics and sub-pixel centroid algorithm provide absolute target position to an angular accuracy of 2.5  $\mu$ rad. The AMS, with special surface mapping software developed at AEDC, calibrated target track during the February pumpdown to position uncertainty within the core field of view (FOV) of less than 7  $\mu$ rad (1  $\sigma$ ). This calibration was "bootstrapped" over the entire 1.2-deg FOV to less than 9- $\mu$ rad uncertainty. The radiometric sensitivity with the focal plane cooled below 50 K is sufficient to see all of the targets in the chamber. With the ability to vary integration times, AMS proved to be a very versatile diagnostic. Using about several seconds to integrate faint signals, stray light problems were found in two sources and corrected. A ghost image in the CSO source was also corrected by inverting the wedged beam combiner. Using millisecond integration times, the AMS was used to calibrate high-speed performance of the Scan Mirror and to demonstrate that the chamber meets its 5- $\mu$ rad jitter budget. In summary, the AMS provides a unique capability in a low-background test chamber and will serve as an invaluable tool for future sensor testing.

## **OPTICAL SIMULATION**

The Chamber Optical System shown in Fig. 3, provides collimation of the Calibration or Scene output, target selection, and single axis azimuth scanning for high-speed target movement and alignment.

### **Collimation Optical System**

The 7V Collimator is a two-mirror off-axis Cassegrain constructed from nickel plated aluminum for cryogenic operation and low scatter performance. The focal length is 1,650 cm, providing a collimated beam of greater than 50 cm diameter with a circular field of view (FOV) of 1.4 deg. The mirrors are coated with enhanced silver and a protective overcoat, providing reflectance of greater than 98 percent from 0.5 to at least 30 microns. Both the primary and secondary mirrors mount independently to the 7V optical bench on actively cooled, massive aluminum structures. Optical quality of the collimator was measured in the 7V during the cryogenic acceptance test in December, 1993. Typical results are illustrated in Fig. 13, showing a HeNe interferogram over the full 50-cm beam at the center field point. The performance at 20 K is excellent, with peak-to-valley wavefront error of about 2 waves at 0.6328 microns, which is equivalent to diffraction-limited performance at 5.2 microns. Over the entire field of view, the full aperture diffraction-limited performance ranges from 4.5 to 6.5 microns. Smaller areas of the beam around 20 cm diameter are diffraction-limited in the SWIR near visible wavelengths. Based on this performance, this optical system is believed to be the finest cryo-mirror system of its size ever built.

### **Scan Mirror System**

The Scan Mirror, mounted between the sources and the collimator secondary, provides high-speed azimuth sweep of the targets across the sensor under test. The light-weighted aluminum mirror rotates about a vertical axis on two stainless flexure pivots driven by a brushless DC servo motor with closed-loop position control from a brushless Inductosyn<sup>®</sup> rotor encoder. In collimated space, this system provides angular position knowledge and resolution of 0.5  $\mu$ rad over a speed range of 0 to 6 deg/sec.

## **SENSOR SUPPORT AND INTERFACING**

Services provided in the 7V for the sensor under test include mechanical support, optical alignment, scanning, thermal control for the focal plane and sensor optics, and electrical interface for power and data transfer. With many years of experience in handling flight-qualified hardware and conducting sensor tests, AEDC can provide any support necessary to accommodate user needs.

### **Sensor Positioner System**

Present capabilities are provided by an existing three-axis gimbal system for pitch, yaw, and roll alignment. This will be replaced by a new Sensor Positioner presently under procurement providing more accurate position control and higher speed scanning with a bandwidth of DC to 5 Hz. Some of the capabilities for both systems are outlined in Table 2.

### **Sensor Thermal Control System**

Thermal control of the sensor under test can be provided for the focal plane, optics, and ambient housing and electronics, if necessary. A dedicated Helium Refrigerator is available for closed-loop cooling of the sensor over a wide range of temperatures

using gaseous helium. This refrigerator can also liquify helium into portable dewars at 75 l/hr, if required. Liquid nitrogen is also available in large quantities, if needed.

## **DATA ACQUISITION AND CONTROL**

The 7V Data Acquisition and Control System, shown in Fig. 14, supports the entire operation of the chamber and execution of the test matrix. Five PCs make up the Test Equipment Control System (TECS) to control and monitor the individual sources and other special test equipment. Two major computer systems, the Chamber Monitoring and Control System (CMACS) and Facility Computer, oversee and supervise test operation and acquire, store, and manipulate data.

### **Technical Equipment Control System**

All of the test simulation equipment discussed above is calibrated, controlled, and monitored by five identical 486 -66 MHz personal computers (Ref. 4). Each PC controls up to 8 stepper motors, 2 chopper motors, and 2 blackbodies or 2 IR detectors in a manual mode for initial checkout or in a fully automated mode for sensor testing. Control parameters for each test scenario, such as temperature, position, and velocity, are downloaded from the CMACS and automatically set up and verified before making a test run. During the run, the TECS monitors and controls test conditions and flags any parameter outside control limits. A user-friendly graphical interface is provided to the operator for monitoring test setup and overall test control.

### **Chamber Monitor and Control System**

The CMACS, based on a Digital 3400 MicroVAX computer, downloads test parameters, sets up, controls, and monitors performance of all chamber simulation and environmental equipment. It provides 256 channels of analog input, multiplexed for chamber control with 16-bit A/D conversion. The CMACS also provides the operator interface to the facility operation through interactive screens. The CMACS MicroVAX computer is installed in the Control Room, along with the analog/digital I/O equipment.

### **Facility Computer System**

The existing Facility Computer, based on a VAX 8650, services the entire AEDC Space Test Complex. It is linked to the 7V over a classified Ethernet to provide overall control of testing through its test parameter database. This database approach provides an efficient technique to run a sensor test by setting and verifying the entire test matrix before the chamber is cooled down. By pre-defining all test conditions for individual data runs, information can be quickly downloaded to the CMACS computer to automatically set up test equipment and monitor performance during the run. Once a test run is complete, sensor measurements and facility information can be uploaded back to the Facility Computer for off-line data analysis, plotting, or archiving while the next data point is being run in 7V. If necessary, the extensive computer facilities available at AEDC are readily accessible from the VAX to an AMDAHL 5860 or a CONVEX 3840 over a classified hyperchannel.

## **SUMMARY**

The 7V Facility provides an advanced test capability for seekers and surveillance sensors up to 50-cm diameter. Its optical system, calibration accuracy, and scene simulation are state of the art. With modern control rooms, environmental systems and data systems, the 7V offers a capability unmatched anywhere for the next generation of infrared sensors.

## **REFERENCES**

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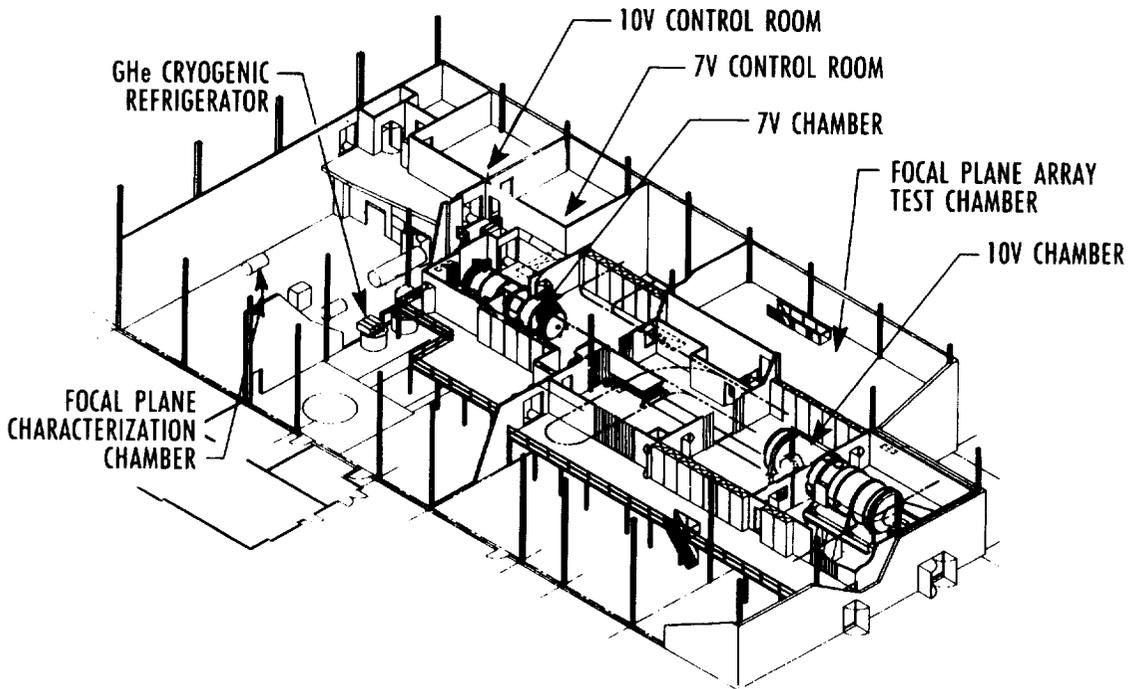
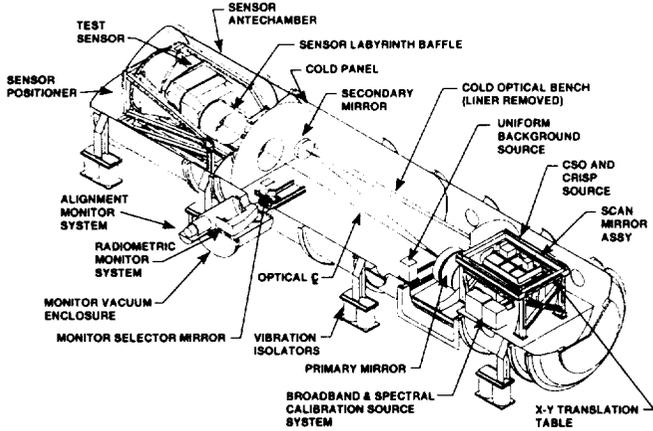


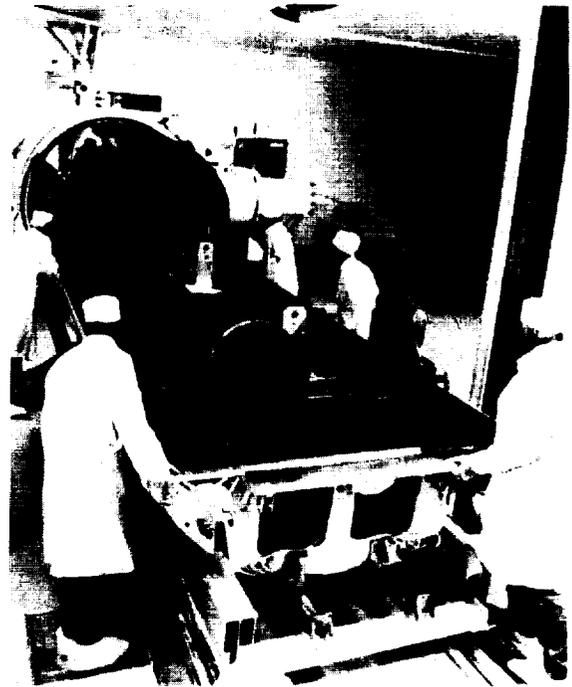
Figure 1. AEDC space test complex.

		DT & E		OT & E	
TEST LEVELS		Component/Sensor Calibration Characterization	Sensor Mission Performance (Open Loop)	Sensor / Platform Performance (Closed Loop)	Deployed System (Integration & Operability)
<b>AEDC TEST ASSETS</b>					
Focal Plane Characterization Chamber		Chips			
Direct Write Scene Generator Chamber		FPA's & Algorithms			
7V Sensor Test Chamber		ATH Surveillance & Interceptor Sensors			
10V Sensor Test Chamber			BTH Surveillance Interceptor Sensors		
Focal Plane Array Test Capability			Sensor Focal Plane Emulators & Algorithms		
Advanced Sensor Test Capability				Multiple Interactive Focal Planes	
		OPERATIONAL	IN BUILDUP	UNDER DEVELOPMENT	

Figure 2. AEDC sensor test plan.



a. Chamber test equipment configuration



b. Optical bench being installed into 7V vacuum chamber

Figure 3. 7V sensor test facility.

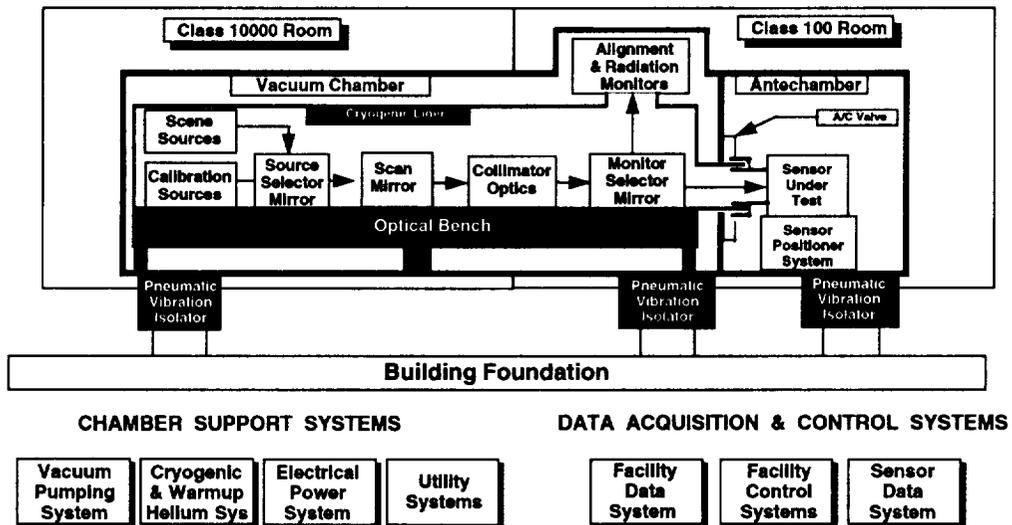
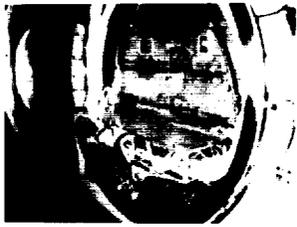
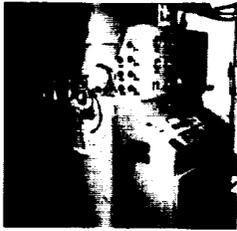


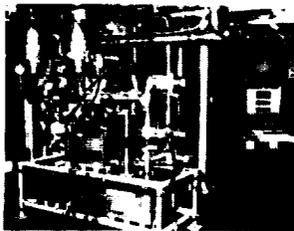
Figure 4. 7V functional layout.



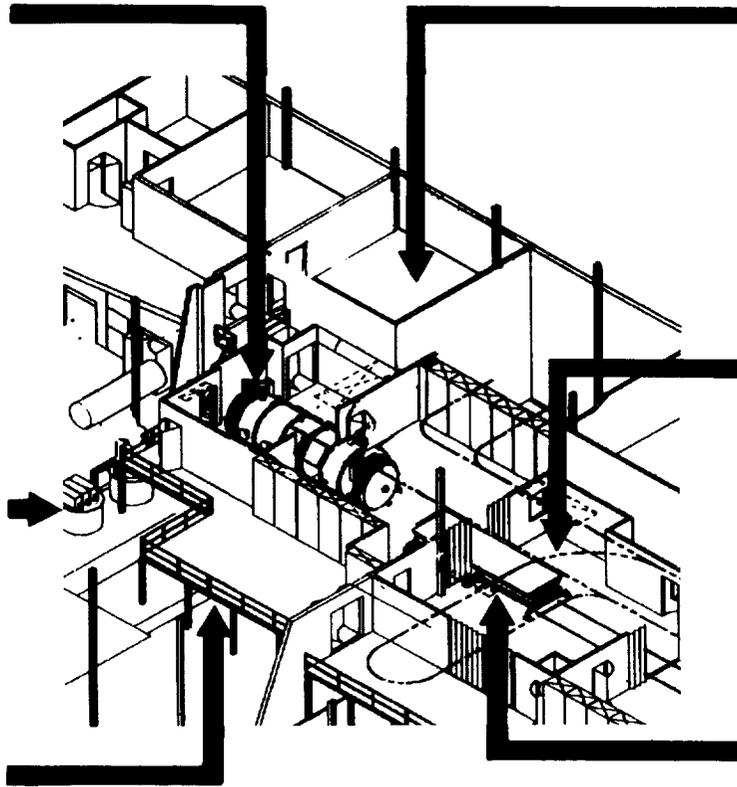
Instrumentation and cryo feedthroughs



Helium refrigeration system



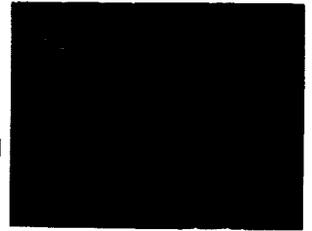
High vacuum system



Test control room



Class 10,000 and 100 cleanrooms



Optical bench and chamber

Figure 5. 7V facility systems.

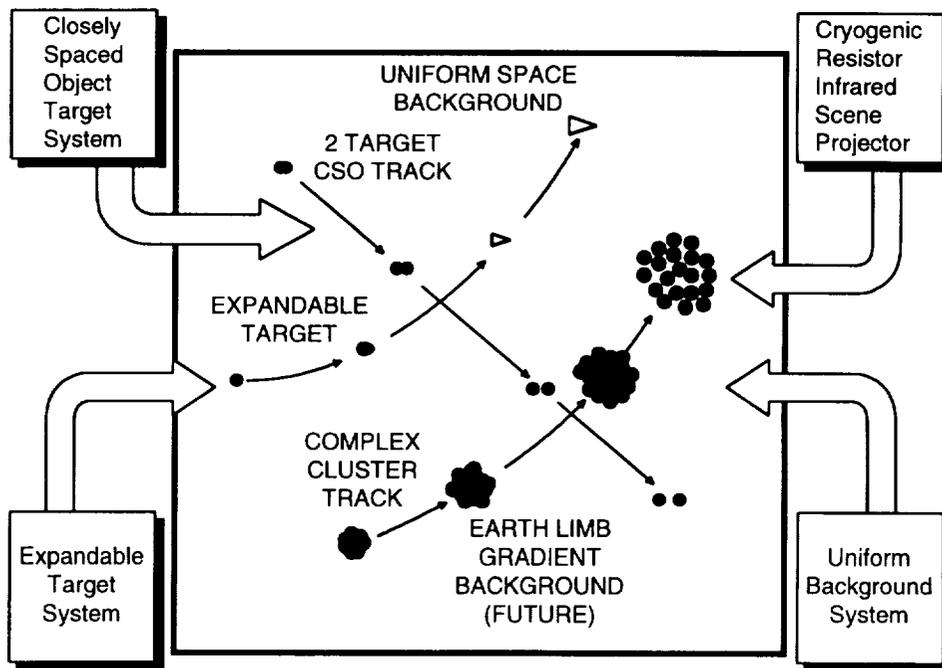


Figure 6. 7V scene simulation.

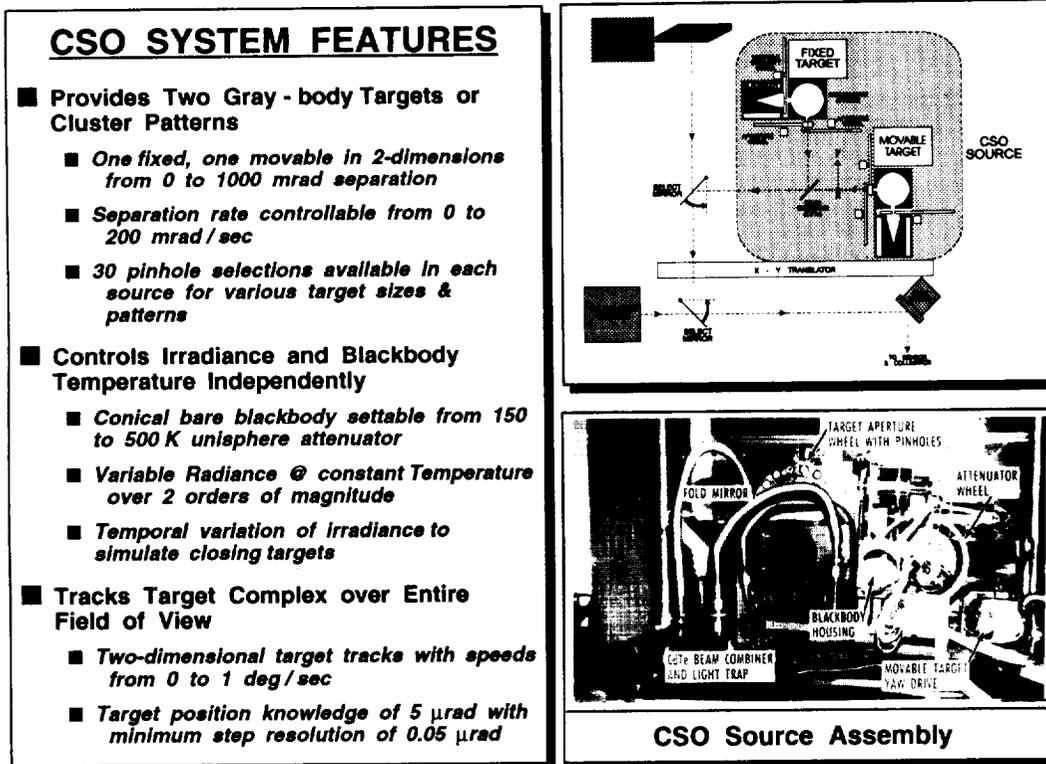


Figure 7. Closely spaced object system.

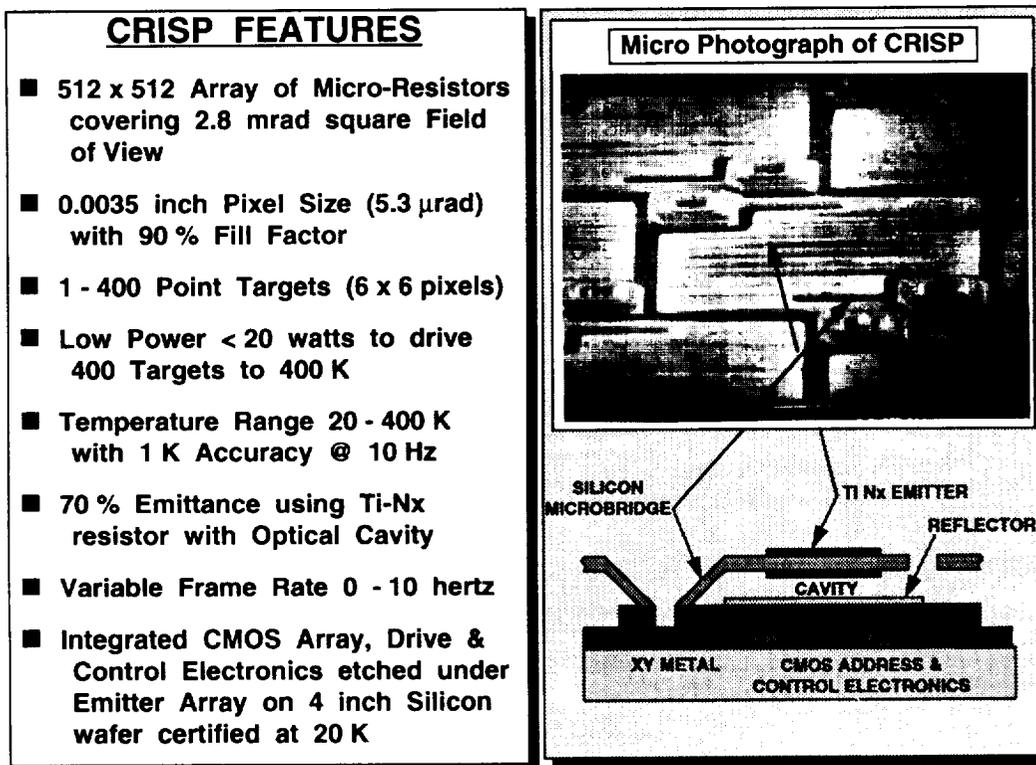


Figure 8. CRISP cluster target system.



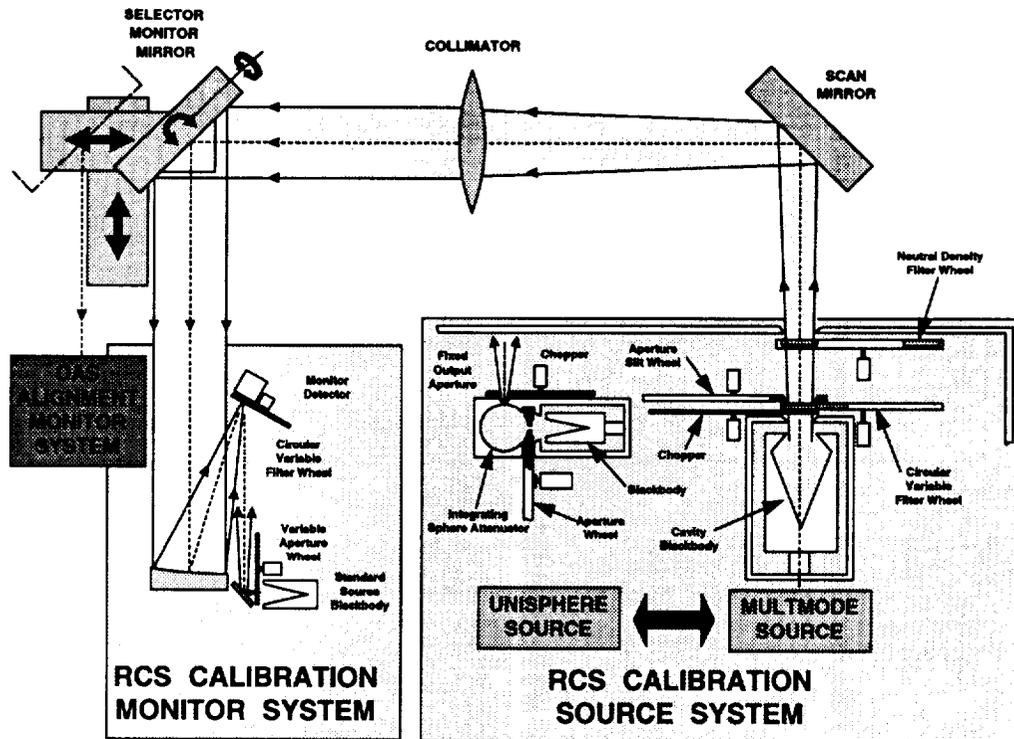


Figure 11. Radiometric calibration system.

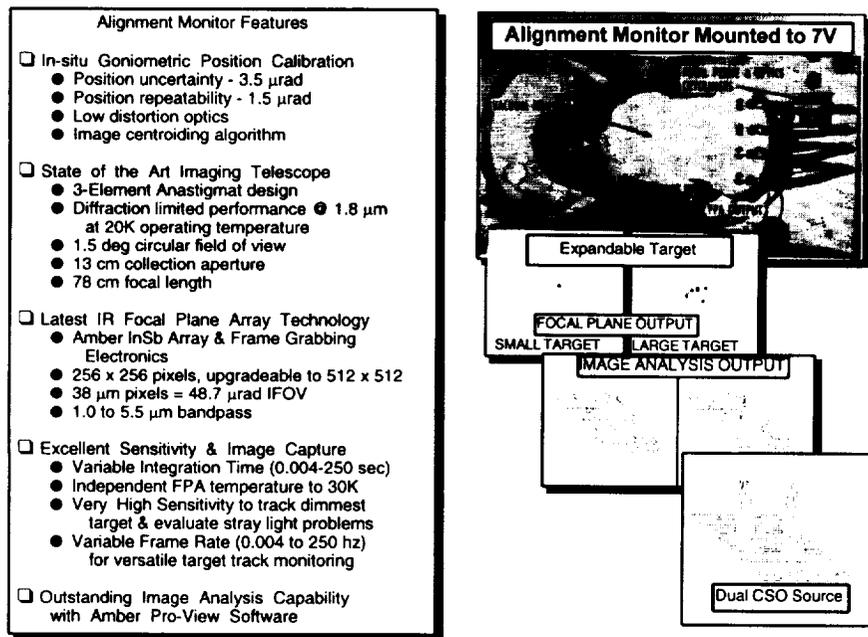
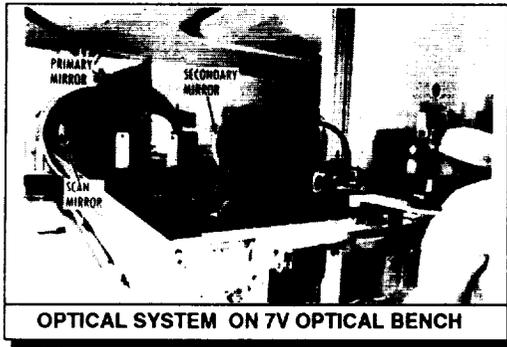
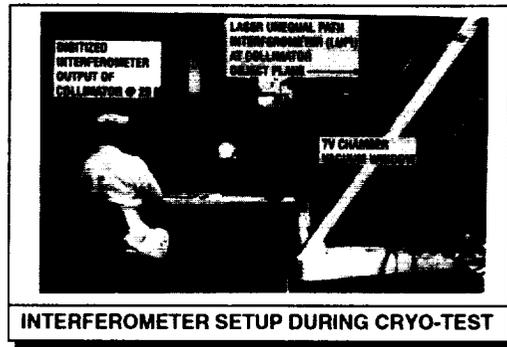


Figure 12. Alignment monitor goniometric calibration system.



OPTICAL SYSTEM ON 7V OPTICAL BENCH



INTERFEROMETER SETUP DURING CRYO-TEST

### CRYOGENIC TEST SETUP IN 7V CHAMBER

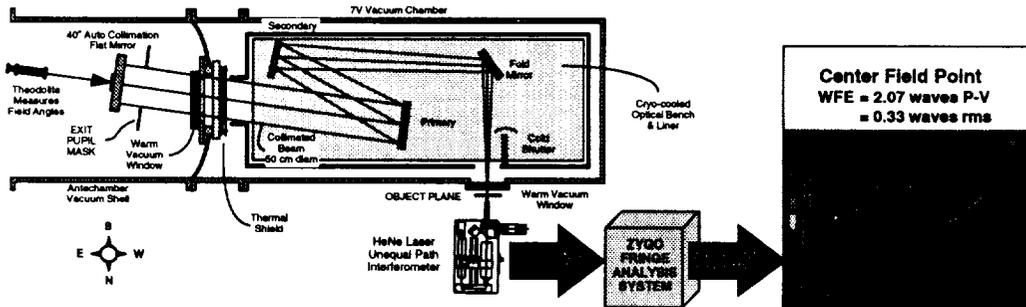


Figure 13. 7V collimator and cryogenic test results.

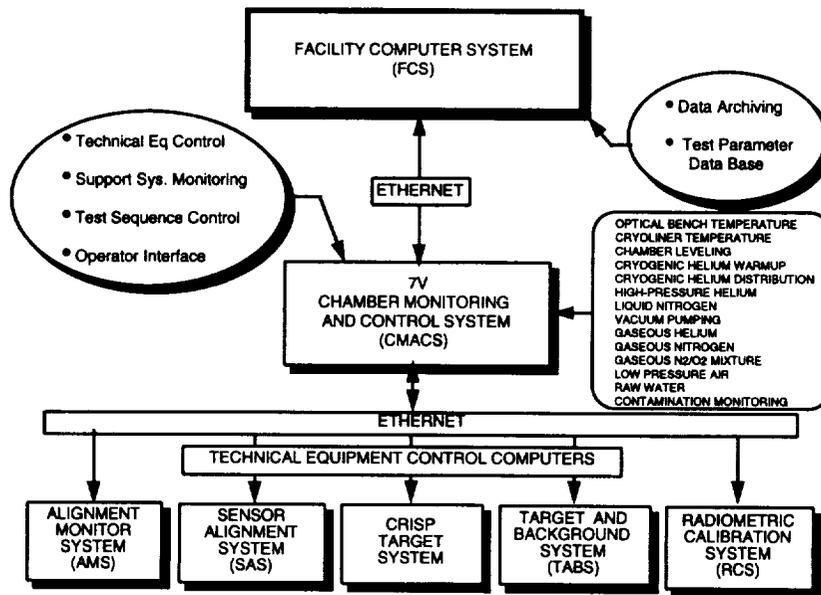


Figure 14. Data acquisition and control system.

Table 1. 7V Chamber Functional Requirements

CAPABILITY	FUNCTIONAL REQUIREMENT
<b>Target &amp; Background Simulation</b>	<ul style="list-style-type: none"> <li>■ Simulate Point Targets, Closely Spaced Objects &amp; Clusters</li> <li>■ Match Spectral Fidelity of Real Targets</li> <li>■ Match Target Motion (Keplerian &amp; Relative)</li> <li>■ Simulate Target Blooming</li> <li>■ Provide Above the Horizon Backgrounds</li> </ul>
<b>Optical Simulation</b>	<ul style="list-style-type: none"> <li>■ Collimate Scenes to Simulate Sensor to Target Range</li> <li>■ Transfer Scene to Sensor under Test &amp; Match Pupils</li> <li>■ Overfill Sensor Aperture &amp; Field of View</li> <li>■ Provide Scan function for Scanning Sensors</li> </ul>
<b>Optical Alignment &amp; Goniometric Calibration</b>	<ul style="list-style-type: none"> <li>■ Provide Reference Alignment of Sources / Optics / Sensor</li> <li>■ Calibrate Target Position &amp; Track</li> <li>■ Certify Target to Sensor Line of Sight Alignment &amp; Jitter</li> <li>■ Certify Optical System Focus</li> </ul>
<b>Radiometric Calibration</b>	<ul style="list-style-type: none"> <li>■ Provide Broadband &amp; Spectral Calibration</li> <li>■ Provide Point &amp; Extended Calibration Sources</li> <li>■ Verify Calibration &amp; Scene Irradiance Traceable to NIST</li> <li>■ Measure Uniformity of Irradiance onto Sensor</li> </ul>
<b>Sensor Support &amp; Interfacing</b>	<ul style="list-style-type: none"> <li>■ Mount &amp; Interface Sensor to Cryo Chamber</li> <li>■ Provide Sensor Static Alignment &amp; Positioning</li> <li>■ Control Sensor Thermal Conditions ( FPA / Optics / Shell )</li> <li>■ Provide 3 - Axis Sensor Movement</li> </ul>

Table 2. 7V Chamber Test Capabilities

7V Test Capability	Value Demonstrated [✓]															
<p><b>Optical Performance</b></p> <ul style="list-style-type: none"> <li>■ Collimated Test Beam Diameter (cm)</li> <li>■ Field of View (deg)</li> <li>■ Transmission (5 surfaces) &amp; Waveband (µm)</li> <li>■ Optical Quality (Wavefront Error)</li> <li>■ Line of Sight Stability (mrad rms)</li> <li>■ Optical Scanning Range / Rate</li> </ul> <p><b>Radiometric Calibration</b></p> <ul style="list-style-type: none"> <li>■ Blackbody Temperature Range</li> <li>■ Irradiance Range (w/cm<sup>2</sup>)</li> <li>■ Irradiance Precision/Repeat/Accuracy (%)</li> <li>■ Spectral Range (µm)</li> </ul> <p><b>CSO Simulation</b></p> <ul style="list-style-type: none"> <li>■ Number &amp; Spacing</li> <li>■ Irradiance Range (w/cm<sup>2</sup>) &amp; Temp</li> <li>■ Target Track Range / Accuracy</li> </ul> <p><b>Complex Target Simulation (FY95)</b></p> <ul style="list-style-type: none"> <li>■ Target Temperature Range (K)</li> <li>■ Position Accuracy / Resolution (µrad)</li> </ul> <p><b>Expandable Target Simulation</b></p> <ul style="list-style-type: none"> <li>■ Size (µrad) &amp; Blooming Rate (mrad/sec)</li> <li>■ Irradiance Change (w/cm<sup>2</sup>) @ Constant Temp</li> <li>■ Rate of Change of Irradiance (w/cm<sup>2</sup>/sec)</li> </ul> <p><b>Background Simulation</b></p> <ul style="list-style-type: none"> <li>■ Uniform Radiance (w/cm<sup>2</sup>/sr)</li> <li>■ Earth Limb Gradient (w/cm<sup>2</sup>/sr/deg) (Future)</li> </ul> <p><b>Sensor Alignment / Positioning</b></p> <ul style="list-style-type: none"> <li>■ Range (+/- Pitch/Roll/Yaw degree)</li> <li>■ Velocity (deg/sec)</li> <li>■ Position Accuracy / Resolution (µrad)</li> <li>■ Frequency Response (Hz all axes)</li> </ul>	<p><b>Decentered Cassegrain all-reflective Aluminum design</b></p> <p>50 ✓            1.2 x 1.2 ✓            88% over 0.5 to 30 ✓            1/4 wave @ 6 mm over 50 cm diam ✓            &lt; 5 ✓            +/- 2 deg Azimuth @ 0 to 6 deg/sec ✓</p> <p><b>Spectral &amp; Broadband traceable to NIST</b></p> <p>150 to 500 K ✓            10<sup>-18</sup> to 10<sup>-12</sup> ✓            &lt; 2 / &lt; 4 / &lt; 10 ✓            2.5 - 14.5 w/ CVF ✓</p> <p><b>RVs / Decoys / Fixed Clusters</b></p> <p>2 @ 0 - 1000 µrad continuous in any direction ✓            1e<sup>-15</sup> - 1e<sup>-13</sup> @ 300K (150 to 500 K available) ✓            2-D Track over complete FOV @ +/- 10 µrad ✓</p> <p><b>1 to 400 Programmable Point Targets</b></p> <p>200 to 400            2 / 5</p> <p><b>Bloomable Triangular or Circular</b></p> <p>30 to 1600 @ 0 to 1.5 ✓            2e<sup>-13</sup> - 2e<sup>-11</sup> @ 300 K ✓            0 to 6e<sup>-11</sup> ✓</p> <p><b>Uniform Space w/ Earth Limb for Future Growth</b></p> <p>1e<sup>-10</sup> to 1e<sup>-6</sup> ✓            1e<sup>-6</sup></p> <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%;"></th> <th style="width: 25%;">Existing</th> <th style="width: 25%;">On Procurement (FY95)</th> </tr> </thead> <tbody> <tr> <td>✓</td> <td>4</td> <td>5/20/60</td> </tr> <tr> <td>✓</td> <td>0.0002 to 0.04</td> <td>0.0001 to 25</td> </tr> <tr> <td>✓</td> <td>+/- 150 @ 5</td> <td>+/- 5 @ 1.7</td> </tr> <tr> <td></td> <td>N/A</td> <td>5</td> </tr> </tbody> </table>		Existing	On Procurement (FY95)	✓	4	5/20/60	✓	0.0002 to 0.04	0.0001 to 25	✓	+/- 150 @ 5	+/- 5 @ 1.7		N/A	5
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